AN OUTBREAK OF BANANA *XANTHOMONAS* WILT IN BANANA ORCHARDS IN WESTERN KENYA

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ABSTRACT

Banana (*Musa* spp. L.) is the third most important fruit crop after avocado and mango in Kenya. In the year 2005, the country produced about one million metric tons of bananas valued at 13 billion Kenya shillings. A bacterial disease caused by *Xanthomonas campestris* pv. *musacearum* (*Xcm*) previously only reported in enset (*Ensete ventricosum* (Welw) Cheesman), in Ethiopia was first reported on banana in Uganda in 2000, Democratic Republic of Congo in 2003, Rwanda in 2004 and Tanzania in 2005. All banana cultivars were susceptible and yield losses of up to 100% were reported in all the above-mentioned regions. The main modes of transmission are: insect pollinators, contaminated tools, infected suckers, unregulated movement of banana materials, and browsing animals. Infected fruits become unpalatable. A survey was conducted in Western Kenya in August 2006 to determine the status of Banana *Xanthomonas* wilt (BXW) in the country. Stratified random sampling was used to select 30 farmers in each district for direct interviews. Banana *Xanthomonas* wilt was found in Teso, Busia and Bungoma districts. Pathogenicity tests confirmed the causal organism to be *Xanthomonas campesris* pv. *musacearum*. Yield losses were estimated to be 80% to 100%. It is recommended that technologies developed and validated in Uganda be employed to manage the disease in a sustainable way in Kenya.

Key words: Banana *Xanthomas* wilt, Outbreak, Kenya, Pathogenicity

INTRODUCTION

Banana (*Musa* spp. L.) is the fourth most important global food crop after rice, wheat and maize in terms of gross value of production. Total world production of *Musa* is currently about 97 million metric tons annually (FAOSTAT, 2003). Banana is consumed either raw as a desert fruit or after cooking or roasting when green/ripe to provide a starchy staple. Approximately one third of global banana production is in the sub-Saharan Africa where it provides more than 25% of food energy requirements for over 100 million people. The East and Central Africa (ECA) sub-region

alone produces nearly 20 million tons of bananas annually, representing 20% of the world output. In addition to providing a relatively cheap and easily produced source of energy, bananas are rich in a number of important minerals and vitamins A, C and B_6. About 20 million people in the ECA region depend on banana for food. Bananas cultivated for export trade account for only 10% of the total output, and hence they are important for food security in the humid tropics and provide income for farmers.

In Kenya, banana is grown for both subsistence and commercial use. It is estimated to cover 74,000 hectares (about 2% of total arable land), ranging from sea level to 1800 m above sea level. In terms of production, over a million metric tons are realised per year. Nyanza and Western provinces account for 64.4% of production, while Central and Eastern provinces account for 26% of production. The rest of the provinces in the country can be classified as being minor producers, with Rift Valley province accounting for 3.9% and Coast province accounting for 5.5% (MoA, 2004). The crop is predominantly grown by small-scale farmers who have an average holding of 0.3 hectares, making up to 13% of the total farm area (MoA, 2005). Recently banana has become an important cash crop for semi-intensive medium scale farmers who supply urban markets in the country. This is more so where the income from traditional cash crops especially coffee have drastically reduced. The continued availability of harvestable bunch from a banana mat is especially important for farmers who are mainly women because it contributes to the year-round security of food and income. The commonly grown varieties are East African Highland bananas and 'Apple Banana' in Western and Nyanza provinces, `Cavendish´ and `Kampala´ in Central and Eastern provinces.

Banana production in Kenya has declined over the last decade due to various problem, including lack of suitable cultivars, diseases, particularly *Fusarium* wilt (*Fusarium oxysporum* f. sp. *cubense*), black sigatoka (*Mycosphaerella fijiensis)*, and pests such as banana weevils (*Cosmopolites sordidus)* and nematodes (*Pratylenchus goodeyi* and *Radopholus similis*), inadequate clean planting materials, high post-harvest losses (40% to 60%) due to poor packaging during transportation and ripening, lack of organized markets and poor infrastructure. The problem of *Fusarium* wilt has been addressed by use of banana cultivars resistant to race 1 and race 2 of the pathogen, `Cavedish´ and the cooking type (Uganda green) as a replacement of the susceptible varieties (the `Gros Michel´ and `Apple Banana´).

Banana *Xanthomonas* wilt caused by the bacterium *Xanthomonas campestris* pv. *musacearum* (*Xcm*) was for long considered a problem of enset (*Ensete*

ventricosum (Welw) Cheesman) in Ethiopia (Thwaites et al., 2000). Banana was known to be susceptible but because banana is an unimportant crop in Ethiopia, BXW was not viewed as an important disease. The first outbreaks outside Ethiopia were reported on a single farm in Mukono district of Uganda in October 2000. The disease was reported in 15 sub-counties in four more districts by June 2003 (Tushemereirwe et al*.,* 2003; 2004). By October 2003, the disease was confirmed in 10 more districts and is currently confirmed in 33 districts (Tushemereirwe and Kubiriba, 2006). Outside Uganda, the disease was first reported in North Kivu province of the Democratic Republic of Congo (DRC) in 2003 (Ndungo et al*.,* 2004; 2006), Rwanda in 2004 and Tanzania in 2005 (Mgenzi et al*.,* 2006). Disease spread has been rapid. In Uganda, the affected area was estimated to be expanding at over 70 km per year. In DRC, surveys showed that the area affected expanded at about 30 to 50 km in one year (Mwangi, Pers. Comm. 2006).

Factors that have facilitated disease spread include human and animal activities, and a combination of natural factors such as contaminated tools, insect vectors, browsing animals and diseased planting materials. All banana cultivars in the survey areas were susceptible. However, work on development of plant resistance through genetic engineering is going on in Uganda (Tripathi et al., 2006). Banana cultivars become most vulnerable to BXW infection at flowering stage since the pathogen can be transmitted between plants by insects that visit flowers for pollen and nectar. Infection through the flower leads to rotting and total destruction of fruits, as well as wilting of the entire foliage. The objective of the present survey was to determine the status of BXW in banana orchards in Western Kenya region.

MATERIALS AND METHODS

Disease Survey

A survey was carried out in Western Kenya region in August and September 2006. The specific target areas were: Teso, Busia, Bungoma, Butere/Mumias, Vihiga, Migori, Siaya, Gucha, Kisii Central, Rachuonyo and Nyamira districts in Western and Nyanza provinces due to their close proximity to Uganda. The Western Kenya region was targeted due to its close proximity to Uganda, the banana trade and unrestricted movement of banana materials across the porous boundaries, and the importance of banana. The survey team comprised of two plant pathologists from KARI-Thika and the International Institute for Tropical Agriculture (IITA), Kampala, Uganda and a horticulturist from Rural Energy and Food Security Organization (REFSO), Busia, Kenya.

The survey questionnaire was designed by IITA. Data were recorded for banana cultivars, disease incidence and prevalence, soil types, banana production practices, banana marketing systems and utilization. The location of the sampling site in each farm was marked by a Global Positioning Satellite (GPS) instrument (Gamin 12 ®). The team visited the District Agricultural Officers (DAOs) of the respective districts for desk top information on banana production. In every district, two main banana growing divisions were selected. An extension officer joined the survey team to the field. Stratified random sampling was used to select 15 farmers from each division. A stratum was taken to be a farmer with at least 30 banana mats in production. The questionnaire was administered by face-to-face interview with the farmers. Thirty mats in each farm were scored for diseases and pests by the enumerators. Pictures of symptoms of diseases, pests and physiological problems of banana that had been laminated and filed were used in visual diagnosis. Pictures of current disease symptoms were taken. In total 365 farms were visited and respective farmers interviewed. Data were analysed using the Statistical Package for Social Scientists (SPSS) version 8.0 and Microsoft excel programmes.

Isolation of Xcm on Synthetic Growth Medium

During the survey, banana samples (pseudostems and fruits) suspected to have Xcm were put in polythene paper bags, sealed and kept in a cold box. In the laboratory, the samples were surface-sterilized by dipping in 5% sodium hypochlorite for 2 minutes, rinsed three times in distilled water and blot-dried. Isolation of Xcm was done on Yeast Peptone Glucose Agar (YPGA). Ingredients of the medium were: 5 g/L yeast extract, 10 g/L peptone; 20 g/L glucose and 15 g/L agar. The medium was poured onto 90 cm diameter Petri dishes and allowed to cool overnight. The following day, the suspect banana plant parts (pseudostems and fruits) were surface-sterilized by wiping with cotton wool dipped in 70% ethanol and cross sections of each made by use of a sterile scalpel. Bacteria were picked from the ooze with a sterile tooth pick and put in 2 ml distilled water in bonjour bottles. This suspension was streaked onto the YPGA plates and incubated at 25^{o}C for 72 hours. A bacterial suspension obtained from these plates was further streaked onto Cephalexin Cellobiose Agar (CCA), a semi-selective medium for *Xanthomonas campestris* according to Mwangi et al. (2006).

Pathogenicity Tests

To confirm pathogenicity, 10 three-month-old tissue-cultured plants of the susceptible banana cultivar `Pisang Awak´ were inoculated by injecting 1 ml of a cell suspension, containing 2 x 10^8 cells/ml, into the stem at 10 cm above the soil level. The inoculated plants were kept for 3 weeks in a plant

incubation chamber maintained at about 25°C with clear polythene sides that allowed normal light during the day.

RESULTS

The major banana varieties grown in western Kenya were: `Cavendish´ (tissue-cultured (TC) and traditional suckers), 'Uganda Green', 'Apple' `Pisang Awak´, `Bokiboki´ and the East African highland bananas. Apart from Kisii region where orchard management was fairly good, management was poor in the rest of the orchards. Banana production was generally low with most of the farmers harvesting an average of five bunches per month. Only 30% of the farmers reported that they de-suckered bananas, although not with sterilized tools. Only 5% of the farmers removed the male flower bud (dis-budded) and most of the other farmers thought that the banana could not mature without the male bud. Majority of the farmers interviewed (90%) planted banana suckers from their own fields or from other farmers (60%), sometimes as far as 80 km away and from neighbouring Uganda. Only 5% of the farmers interviewed had grown tissue-cultured bananas.

The major pest and disease problems identified were banana weevil, *Fusarium* wilt, banana streak virus (BSV), black sigatoka, and nematodes. The survey team noted that most of the extension field officers and farmers could not differentiate *Fusarium* wilt symptoms on banana from those of banana *Xanthomonas* wilt when shown the colour photographs of the two. While the team was driving along a tarmacked road connecting Malaba and Busia in Chakol division of Teso district, a banana bunch with symptoms similar to those of BXW was observed on one banana mat of `Ndizi Sukari´ (popularly known in Uganda as `Kayinja´) and in India as `Pisang Awak´. The symptoms were: shriveled male bud and premature ripening of fingers. Cutting across the fingers revealed a brownish discoloration in the pulp. The disease was observed in other fields in Amukura division in Teso district and Malakisi division in Bungoma district. The banana cultivars affected were `Bokiboki´ and `Ndizi Sukari´. On the foliage, there was general yellowing of leaves starting from the oldest similar to that of *Fusarium* wilt. However, when the infected pseudostem was cut, there was a characteristic yellow ooze of bacteria (Plate 1). Cutting across *Fusarium* wilt-infected banana plants will show a brownish discoloration but no bacterial ooze.

Farmers alleged to have seen the first symptoms in a field in Chakol division in April 2006. By the time of the survey (four months later), the disease had spread within a radius of 20 km in the district with another outbreak 40 km away in Bungoma district. Yield losses were estimated to be 70% to 90 %.

Isolation of Xcm

After 72 hours of incubation, bacteria colonies on YPGA were light-yellow, circular, high convex, very mucoid which is characteristic of Xanthomonads. Pure individual colonies (Plate 2) were further obtained after transfer onto CCA and identified based on colony appearance and growth characteristics (Mwangi et al., 2006).

Plate 1. Bacteria ooze from a pseudostem

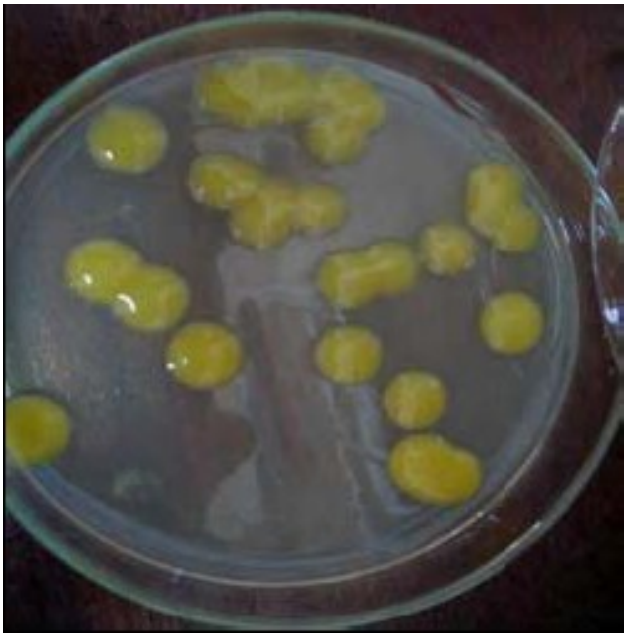

Plate 2. Pure colonies of Xcm on YPGA

Pathogenicity

Three weeks after inoculation, all the inoculated plants expressed symptoms on the leaves similar to those observed in the field and the bacterium was re-isolated from infected stems (Plate 3). The control plants, injected with sterile distilled water, remained healthy. The pathogen was re-isolated from the wilted plants and confirmed to be *Xcm* on the basis of growth characteristics on YPGA and CCA.

Plate 3. Banana seedlings wilt (left) after inoculation with Xcm cell suspension. Control (healthy) banana seedlings are on the right.

DISCUSSION

The high incidence of *Xanthomonas* wilt in the region could be explained by two factors, presence of the susceptible banana cultivars (‘Apple Banana’, `Bokiboki´ and `Ndizi Sukari´ or `Kayinja´), and recycling of on-farm banana suckers. Suckers with latent infections can serve as carriers of the pathogen within the farm or from one field or region to another. All banana cultivars are susceptible to BXW but the most susceptible (due to presence of sweet nectar and floral morphology) are the `Bokiboki´, `Ndizi Sukari´, and the ‘Apple Banana’. It was noted during the survey that `Bokiboki´ and `Ndizi Sukari´ are normally left unattended and the farmers would only go to harvest a bunch when there was one. This implies that in the event of infection, the farmer may take long to notice the disease. These unattended banana mats may serve as a reservoir for the *Xcm*. Breaking of the male flower bud immediately after pollination (11 days after flower opening) can effectively reduce insect transmitted *Xcm*. However, farmers in Western Kenya not only fail to remove the male bud but believe that removal can harm the banana. Presence of the cushions (scars) left behind by fallen flower parts increases the risk of bananas to insect transmitted BXW

infection. The bacteria can also be transmitted through contaminated tools that farmers fail to disinfect after use.

Disease spread in Uganda was slowed after prompt action was taken. This included aggressive creation of awareness. Once the community is well sensitised it is able to identify the disease and to effectively control it. Through a participatory development communication (PDC) process, the community is able to develop its own communication tools (Mass media, electronic and print media, drama, bill boards, going public, posters, fact sheets etc) for BXW management. At national level in Uganda, task forces to manage the disease were formed. Political support gave the taskforces power to formulate and enforce community by-laws (Kubiriba and Tushemereirwe, 2006) for disease management. Continuous monitoring to detect new BXW outbreaks and determine disease trends was put in place to sustain control efforts for the disease. Capacity building for BXW control was done through training of trainers, stakeholders' workshops and establishment of coordination systems.

CONCLUSIONS AND RECOMMENDATIONS

Banana *Xanthomonas* wilt is now in Kenya. Food security for over two million people in Western Kenya is at risk due to the devastating effects of the disease. Most of the players in the banana value chain in the country are not aware of the disease and chances are that if no action is taken the disease will spread to other areas. Currently, the areas where the disease has been confirmed are not major banana growing areas. If quick action is taken, the disease spread can easily be stopped before it spreads to major banana growing areas. However, due to banana not being so important in these areas, farmers may not be willing to put their energy into disease management (destruction of the infected plants, removing the male bud, sterilizing farm tools). This means these areas will continually be sources of inocula and create danger of potential disease spread to other areas. If the disease gets to areas where the level of banana orchard management is high (like in Kisii where pruning is practiced), one farmer could potentially spread disease to 200 plants per day through contaminated tools.

There is need for formation of a national task force composed of staff from the Ministry of Agriculture (MoA), Kenya Agricultural Research Institute (KARI), Kenya Plant Health Inspectorate Services (KEPHIS) and Horticultural Crops Development Authority (HCDA) to map a way forward for management of BXW in Kenya. Communities in western Kenya should be mobilized to manage the disease using technologies developed and validated in Uganda. This opportunity can be used to train farmers in the

region in good banana management. After destroying the infected plants, farmers should leave the land fallow or plant other crops for at least six months. The farmers should be linked to a source of clean planting material (tissue-cultured or micro-propagated). The country has several public and private tissue culture laboratories from where farmers can source clean planting material. The farmers may need to be linked to a micro-credit scheme to get loans for the same.

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